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Effect of Different Substrate Temperatures and Compound Fabrication of Cadmium Telluride (CdTe) Thinfilm Solar Cell by SPD Technique

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ABSTRACT

Spray Pyrolysis deposition **(**SPD) method has been employed to prepare p-CdTe thin films onto glass substrates under various ambient conditions. The precursor solution for the Spray containing dissolved Cadmium Chloride ($CdCl_2$) and tellurium dioxide (TeO_2) with 1:4 ratios of ammonia reagent and distilled water. In order to study structural and optical properties, films having different thickness have been prepared by changing suitable deposition conditions. The X-ray diffraction (XRD) study shows that polycrystalline nature of the film. The interplanar distance, grain size dislocation densities were taken from XRD pattern of CdTe film. Scanning electron micrograph revealed the formation of densely packed, compact and large grained surface of CdTe films. UV-VIS study showed high optical absorption coefficient exhibiting direct band gap of the deposited thin films are in the solar energy range. The CdTe thin films having semiconducting behavior with p-type electrical conductivity and the solar performance of CdTe absorber layer has been examined with their values are recorded.

Keywords: SPD, p-CdTe, Cadmium Chloride, XRD, absorber layer, Solar Cell.

1. INTRODUCTION

CdTe thin films are regarded as one of the most promising materials for heterojunction thin film solar cells. CdTe is one of the most important semiconductors because of the direct band gap energy (Eg=1.45 eV), and the high conversion efficiency of terrestrial solar light in electricity. CdTe has been used as the suitable potential material together with several semiconductors such as CdSe, CdS, with high efficiency. The deposition of CdS films has been explored by different techniques. But all these methods have sophisticated requirement in other to precise temperature control, high pressure etc. Besides all above methods Spray pyrolysis Deposition (SPD) technique is simple, convenient and cheaper[1-4].

The main advantages of this technique are: minimum volume of the solution is required for large area coating than the conventional spray technique, reusability of the solution is avoided as the solution which has been triggered gets completely sprayed, no need to maintain the spray rate of the solution as in the conventional spray technique[5].

2. EXPERIMENTAL DETAILS

The spray pyrolysis technique is a simple technology in which an ionic solution-containing the constituent elements of a compound in the form of soluble salts-is sprayed onto over heated substrates using a stream of clean, dry air. The CdTe thin films were prepared by spraying an aqueous Solution of cadmium chloride (CdCl2) and tellurium dioxide (TeO_2) with 1:4 ratios of ammonia reagent and distilled water on glass substrate kept at 350^0C. The automization of the chemical solution into a spray of fine droplets is effected by the spray nozzle, with the help of compressed air as carrier gas. The spray rate was about 14ml/min. through the nozzle ensures a uniform films thickness.

The structural study of this film was carried out by X-ray diffraction, Scanning electron microscope (SEM) and optical properties in the UV-VIS region by spectrophotometer.

3. RESULTS AND DISCUSSION

3.1 XRD analysis

The structural analysis of CdTe thin films was carried out by using X-ray diffractometer. The X-ray diffraction patterns of the CdTe thin films, grown at different spray sequences on glass substrates are shown in Figure 1.The XRD analysis shows that the thin films are face-centered cubic (a=b=c) phase CdTe with lattice parameters a = 6.397Å which is almost in agreement with the standard data from JCPDS card No 15-0770. The planes are oriented in the direction (111), and (311). The films exhibit cubic crystal structure. The highest intensity peak corresponds to (111) preferred orientation. The (111) peak is stronger than other peaks. In general, the preferential orientation of the films is along the (111) direction. The reason for relatively lower peak intensities is the lower film thickness and formation of a nanocrystalline phase in the films[6].

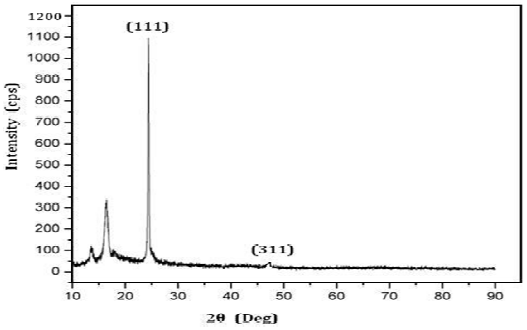
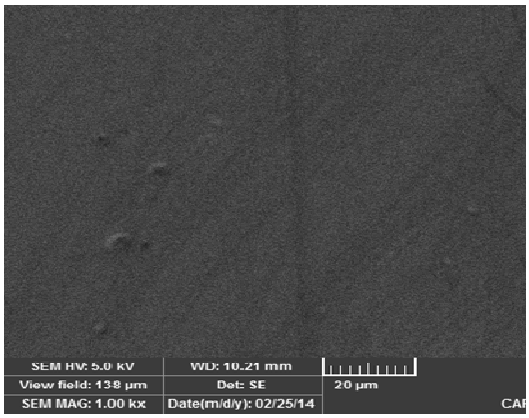
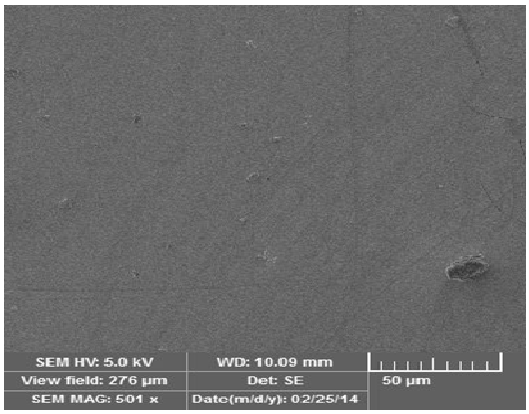


Fig.1 XRD pattern spectrum of the CdTe film

3.2 Morphological analysis



(a)



(b)

Figure 2: The SEM image of the CdTe thin film (a) 20 µm (b) 50 µm

Fig. 2 shows the surface (SEM) image of annealed CdTe film. CdTe film composed of particles having size ranging from 250 to 300 nm. Particle size and crystallite size are different. Crystallite size is always smaller than particle size because a particle constitutes many crystallites.

3.3 Optical Properties

The optical absorption coefficient versus the photo energy of the CdTe film can be seen that the annealed film has a large optical absorption coefficient, which is larger than $10^4 cm^{-1}$ in the visible wavelength region indicating the value is suitable for solar cell applications of thin films. The optical band gap energy of the CdTe film can be estimated from the $(\alpha hv)^2$ versus hv graph by extrapolating the linear absorption edge part of the curve. The result shows that the optical band gap of the CdTe film is around 1.45eV[7].

4. CHARACTERIZATION OF THE CELL

For the spray deposited CdTe/CdS material, the power conversion efficiency (η) of the device was relatively 2.76%, since the data of photovoltaic parameters such as Jsc, Voc, and FF were obtained.

4. CONCLUSIONS

The spray pyrolysis deposition of CdTe thin films and the effect of substrate temperature have been studied. The optical and morphological analyses of prepared films have been done. The energy gap of the synthesized material is found to vary between 1.5 eV and 1.4 eV. The films prepared with the optimized deposition

parameters show preferential orientation along (111) plane. The SEM study shows the smooth and uniform growth of spherical-shaped grains on substrate surface with a crack free appearance and the average grain size was found to be 250 nm. Morphological studies revealed an increase in the crystallite size with the increase in substrate temperature from 423^0C - 673^0C. The band gap of the CdTe thin films decreased with increase of grain size and substrate temperature. Single-junction CdTe/CdS solar cells are obviously interesting for terrestrial and space applications. Such solar cells with TCO contacts are expected to be more stable than conventional cells with metallic back contacts, because of their chemical robustness and compatibility. Using a low-temperature process, this is suitable for the development of flexible cells on polyimide. The CdTe thin films having semiconducting behavior with p-type electrical conductivity and the solar performance of CdTe absorber layer has been examined with efficiency 2.76% and their parameters are recorded.

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